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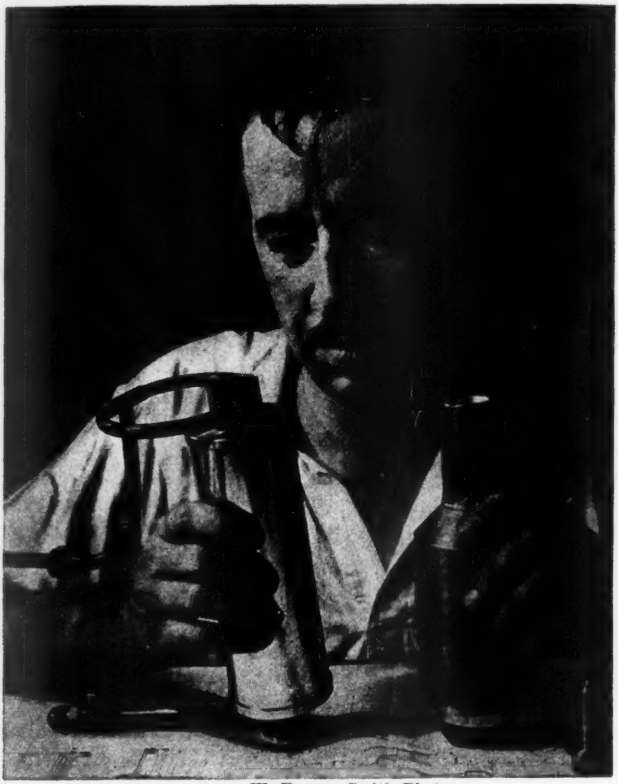

W. Eugene Smith Photo

A ROCKETOR PONDERS—Two stages of progress represented by an early uncooled motor (right) and the Wyld regenerative design. Engineer John Shesta meditates on the next step forward.

THE AMERICAN ROCKET SOCIETY was founded to aid in the scientific and engineering development of jet propulsion and its application to communication and transportation. Three types of membership are offered: **Active,** for experimenters and others with suitable training; **Associate,** for those wishing to aid in research and publication of results, and **Junior,** for High School students and others under 16. For information regarding membership, write to the Secretary, American Rocket Society, 50 Church Street, New York City.

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The American edition of **"Rockets Through Space"** by P. E. Cleator has been exhausted. However our Library department can obtain a limited number of copies of the fast dwindling English edition at $3.00 each. Write at once to be sure of your copy.

Members willing to part with early issues of **Astronautics,** in particular Nos. 1 to 10, are requested to communicate with the Secretary. Also needed are a few copies of Dr. Goddard's report on **"A Method of Reaching Extreme Altitudes".**

Answering the call for action from Lt. Com'd'r. Miller in this issue, Mr. Alfred Africano has made a preliminary study of the possibilities of rocket-projectiles in aerial warfare. Watch for it in the next issue.

Powder Flight Tests

Report on Shots of Commercial Types

Twelve standard powder rockets submitted by the Unexcelled Fireworks Company were tested for altitude by the Experimental Committee of the American Rocket Society at Mountainville, N. J., on November 19th, 1939.

The assortment consisted of three samples of each of the sizes designated as 2 lb., 3 lb., 4 lb. and 6 lb. Actual weight of these charges is very much less than these figures. The rockets were provided with regulation length sticks, but the star shell "payload" was removed, hence the heights reached were greater than can be expected in normal service.

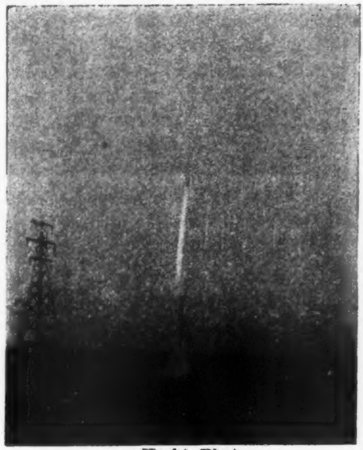
Method of Firing

A length of pipe was set up vertically, with its lower end driven into the ground. The stick of each rocket was slipped loosely into the pipe, and the rocket fired in this position. The flight of each rocket was observed by means of two range finding instruments stationed on either side of the launching point, some 500 feet each side of it.

The weather conditions were favorable, visibility good, scattered clouds and very little wind.

Altitudes Attained

Shot No.	Rocket Size	Height
1	2 lb.	Lost by observer
2	2 "	506 feet
3	2 "	624 "
4	3 lb.	779 "
5	3 "	769 "
6	3 "	730 "
7	4 lb.	892 "
8	4 "	861 "
9	4 "	830 "
10	6 lb.	1083 "
11	6 "	825 "
12	6 "	803 "



Hecht Photo

Soaring Upward on Flametail

It will be noted that these flights were uniformly higher than the altitudes reached by the models powered by these charges in the September shooting. The model rockets were naturally larger both in length and cross-section, heavier and in some cases carried accessories, such as smoke pots. The question has also been raised as to whether these models would not have risen higher if shot free, rather than started by the rubber-powered launching car. Future tests will help ascertain if this is true. They will also settle the problem of stability, which was brought to the fore by the unusually good stability of the stick-equipped charges.

The performance of the rocket range finders will be made the subject of a separate report.

John Shesta, Chairman,
Experimental Committee

Jet Propulsion For Airplane Take-Off

Exploring a New Field for The Rocket Motor.

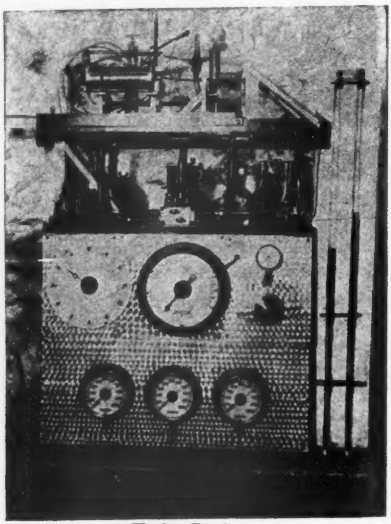
By ROY HEALY

ALL who have studied the possibility of jet propulsion for aircraft have agreed that for speeds below 600 M. P. H., and beneath stratospheric levels, this method of motivation cannot compete with the present aircraft engine and propeller combination in efficiency. Analysis reveals that rocket power will come into its own only where other methods start to fall off: at high speeds and high altitudes. Yet, paradoxically, one of the most immediately promising fields for its use is one in which low speed is combined with sea level altitude. Despite its very high fuel consumption in comparison to other engines, the rocket motor could well be utilized for assisting the take-off of heavily loaded airplanes.

The Take-Off Problem

The outstanding obstacle to higher payloads and longer cruising ranges for modern planes is the limitation imposed by their take-off performances. Wing lift increases roughly as velocity squared and when the loading of a plane is increased its take-off speed will also necessarily rise. The early trans-Atlantic attempts with their long and hazardous ground runs dramatically emphasized the difficulty of getting off the runway with a very heavy load.

The take-off problem has been attacked from two angles; improvements in the plane itself and the application of external power to launch the plane into the air. Development of more efficient airfoil sections has greatly aided performance by creating a higher lift coefficient at a given speed. Numerous experiments with flaps and slots have been conducted to add lift during the ground run, and in some instances have shown promise, particularly the Fowler type extensible flap. The great disadvantage of high lift devices of any type is that they also greatly increase drag when the engine is struggling to accelerate the plane to its lifting velocity, hence neutralizing most of the



Hecht Photo

A. R. S. Test Stand No. 2, soon to be modified for larger motors and longer runs. Arrow indicates motor.

good they contribute. For landing, an increase in drag is useful, for the plane is decelerating. Most modern planes are equipped with landing flaps, but at present no airliner or bomber in this country uses high lift devices to aid take-off.

The incessant demands from commercial and military sources for more power for take-off has been a big factor in bringing about the modern high-powered airplane engine. This necessitated the controllable pitch propeller to efficiently utilize the added power at various altitudes.

The majority of large engines are supercharged to deliver maximum power for one minute periods during take-off. This time limit is imposed to prevent excessive cylinder temperatures and consequent burnouts. Use of this added power, in addition to a very drastic cleanup in external lines, has boosted wing loadings from the 15 lbs. per square foot of ten years ago, to an average of 25 to 30 lbs. per square foot for today's big planes. It is interesting to note that Howard Hughes' Lockheed on taking off for his world flight had the unprecedented loading of 49 lbs. per square foot. Only when a ground speed of 125 M. P. H. had been reached at the end of one of the world's longest runways did it manage to stagger into the air.

Thrust and Ground Run

To accelerate a plane from rest to its lifting speed the static thrust developed must overcome the retarding factors of wheel (or water) friction and air resistance. The former falls off as more and more of the weight is borne by the wings, while the latter rises. The greater the excess of thrust the higher will be the acceleration rate and the shorter and more rapid the take-off.

Not only is take-off performance important in relation to the plane's payload and range but it is of great significance in determining the size and cost of modern airoprts. Huge airports near large cities, such as the new field at North Beach, N. Y. C. with its 6000 foot main runway, are tremendously costly to construct and maintain. This has a direct bearing on the cost of transport operation as high fees must be paid by the airlines.

Under wartime conditions small emergency fields must often be pressed into service. Heavy bombers would have to whittle their loads unless assisted at take-off. In this case the higher acceleration imparted by added power would be utilized in getting the normal load off the ground in a shorter run. For use on large fields the load could be greatly increased and the standard length run retained.

Flying Boats

To avoid the limitation imposed by airport runway lengths designers of large, heavy aircraft have in some cases turned to the flying boat and seaplane types to take advantage of the longer surfaces of bays and sounds. Unfortunately water drag is much higher than wheel friction so that the accelerating rate is even lower and a corresponding longer run is necessary before the plane will lift. Hazard is also increased by the chance of upsetting in rough water, hitting of driftwood or small boats, as has happened several times in the ocean crossing trials. Another objection is the increased air resistance of flying boats and seaplanes over land planes of equal capacity, due to the marine nature of their hulls or floats.

Most designers are inclined to the belief that the land plane will eventually replace flying boats even in transoceanic travel.

Ship Catapults

To date the only method of external assistance to prove its merit in continuous service is the ship catapult. Indispensible for many years to the world's battle fleets there has lately been a trend to its use for commercial purposes. Mail service from ship to shore can be expedited in this manner as has been shown in trials.

The methodical series of ocean mail flights by the Deutsche Luft Hansa before the war's outbreak, marked the most ambitious use of the ship catapult. The equipment used on the midway ship "Friesenland" was capable of launching planes up to 37,000 lbs. gross weight. The size of the four-motored "Nordwind" and "Nordmeer" indicated the power of this accelerator. While an excellent means of mail transport with trained crews, the high acceleration factor of 2 to 2½ G rules this means out for passenger service.

Land Catapults

A land catapult was used by the Wright brothers in the first powered flight. Today some recommend a return to this method for getting heavy planes into the air. The Royal Aeronautical Establishment some years ago undertook a research program at Farnsboro using land catapults or accelerators for launching military planes. A telescoping cylinder arrangement with direct thrust was used in some trials. More practical and less strenuous was a method using a cable and trolley to which the plane's tail was fastened. The cable was wound around a drum powered by 2 compressed air engines. It ran from the drum to a pulley fixed into the field then back to the tail trolley. Planes up to 18,000 lbs. weight lifted in a 120 foot run under 1 G acceleration, yet the method was never put into service.

The Composite Airplane

An unusual and spectacular attack on the problem was Major R. H. Mayo's composite aircraft, popularly known as the "pick-a-back plane". Taking off from the water unaided the upper component's range was limited to 1500 miles. When released at 5000 feet by the powerful mother plane this range increased to 3500-4000 miles. Despite a successful round trip across the Atlantic this method does not appear to be acceptable as a solution. The main drawbacks are the high cost of the parent planes, the need for a heavy crane to lift the upper ship in place, a locality with quiet water to prevent damage in joining, and the necessity for great skill when separating in the air.

Fueling in Flight

As a plane can fly with a much greater load than it can lift off the ground the possibility of fueling while in flight has often been considered as a means of reducing take-off loads. Present equipment have transfer rates as high as 80 gallons per minute. This method is well suited to individual record-breaking flights, but is hardly practicable for large scale operations. A fleet of refueling planes and their trained crews would not only be costly, but would clutter up the air around airports where frequent schedules are maintained. It is obvious that a formation of bombers would be very difficult to fuel up in this manner.

Rocket Power

The Junkers plant at Dessau, Germany, conducted tests with a heavily loaded seaplane of the Ju 33 type, during 1929, using a number of powder rockets to assist the take-off. Clipped to the under surface of the wings, the cartridges were dropped off after they had helped lift the plane into the air. Official word of the tests claimed them "successful and very promising" but no further trials were ever reported. Much ado was made in the newspapers and popular magazines about a number of flights powered by several powder rockets. These were nothing but stunt flights and of questionable scientific value as little if any data was ever published.

The future of rocket power, of course, lies not in these crude unstable powder rockets, but in the much more powerful, controllable, liquid fuel motors such as have been tested by the American Rocket Society, Goddard, Sanger, Valier and Heylandt, the German Rocket Society and others.

The 200 : 1 Ratio

The initial goal of serious rocket experimenters both here and abroad has been the development of a meteorological rocket to replace the sounding balloon now used for gathering weather data. A motor thrust of 100 to 200 lbs. was considered sufficient for this purpose and the units so far tested have been quite small.

After making several trial flights of liquid fuel rockets, each of which ended prematurely in mishap, the Experimental Committee of the American Rocket Society decided to confine its efforts to proving stand tests until greater motor dependability had been achieved. The resultant program of research, while only scratching the surface due to scarcity of funds and facilities, is the only dependable source of information available on rocket motor performance.

Outstanding among the facts so far unearthed is this: present day motors burning ethyl alcohol and liquid oxygen can produce a thrust of 200 lbs. for each lb. of combined fuels consumed.

The best powder rockets obtainable give a thrust ratio of about 50 lbs. per lb. of powder consumed, and have the great disadvantage of being absolutely uncontrollable while burning. The duration of their thrust period is usually only a second or two.

It is obvious from this that loose talk of rocket planes will have to be grounded until the 200 : 1 ratio is increased tremendously.

At the present effiicency a motor of even 1000 lbs. thrust would consume 5 lbs. of propellants per second, 300 lbs. per minute and 18,000 lbs. in an hour's flight. Nonetheless the extreme lightness of the motor in relation to its power output, its evident low initial and maintenance costs, and the simple equipment necessary for its operation suggests that the present motors are not to be ignored in the attack on the problem of take-off.

Power Comparison

During the take-off run a high powered airplane engine, geared down and equipped with a constant speed propeller, develops approximately 4 lbs. thrust per horsepower. Under normal conditions there is a tendency for this thrust to decrease in direct linear relationship to the speed increase, however the figure of 4 lbs. may be taken as a reasonably correct average for modern planes. Totaling the weight of the engine and propeller

results in a figure of from 2½ to 3 lbs. thrust per lb. of powerplant. Contrasted with this our experiments indicate large rocket motors should easily yield 50 lbs. thrust per lb. of motor weight. In addition the static thrust of the jet will have a tendency to increase with speed.

Thrust Augmentation

By moving a large mass of air backward at comparatively low speed the propeller method shows a much higher thrust return per lb. of fuel consumed than does the rocket jet. The latter in exhausting a small mass backward at very high speed loses over 90 per cent of its kinetic energy to the surrounding air. Since jet velocity must be as high as possible this shock loss can be partly overcome by accelerating the air which is to come into contact with the jet gases, by utilizing a Venturi cone surrounding the motor. N. A. C. A. research indicates possibilities of increasing thrust from 10 per cent to 50 per cent by using such an augmentor.

Work is now under way on a motor considerably larger than any so far tested which is to utilize this Venturi principle. ..ot only is thrust augmentation planned but the large quantities of air sucked in by the jet will pass over longitudinal cooling fins covering the motor and nozzle. By this method a simple and reliable cooling action is expected. Unlike other engines where the cylinder temperature must be kept low to prevent burning of lubricating oil, preignition and seizing of parts, the temperature of the rocket motor is limited only by the melting point and hot strength of the materials of which it is constructed. It is reasonable to believe the air cooling action will prevent burnouts during the brief time the motor will be called on to function.

Liquid Oxygen

Reluctant to depart too far from convention many approaching the subject of rocketry have asked, "Why not use the free surrounding air for burning the fuel?". Experiments with gasoline turbines and mathematical investigation by the N. A. C. A. and others have shown that the power required to drive the compressor would just abuot equal the power derived from the jet. The recent report of the British air driven plane will have to be further amplified before it is clear whether they have overcome this difficulty.

The unanimous opinion of the American Rocket Society experimenters is that the oxidizing agent should be carried in the most compact form available—liquid oxygen. This substance, which boils off at temperatures above -182.5°C, presented several difficulties of usage when obtained for the preliminary experiments. Since that time the Society has developed a technique of handling, storage, pouring, pressure feed, etc. which greatly increases its practicability.

Cost of Rocket Power

As ethyl alcohol requires 2½ times its weight of oxygen for complete combustion it is easily seen that the price of oxygen will be the major factor in a cost analysis of rocket operation. At present the liquid is not readily available in all localities and cost will vary with accessibility. In the New York area it is obtainable for about 10 cents per lb. When the demand increases it should sell for about one-half this figure. Present manufac-

(Continued on Page 16)

Rocket Power From Atoms?

Enormous Energy Is Contained In Matter, But Can We Tap It?

By G. EDWARD PENDRAY

WHEN Albert Einstein wrote his special theory of relativity in 1905, he included a mass-energy conversion equation which not only assumes that matter and energy are two different forms of the same thing, but suggests how puny are all our present sources of power as compared with the enormous quantities of energy that lie unused in every iota of matter and substance about us.

As stated in most reference books, the Einstein equation is:

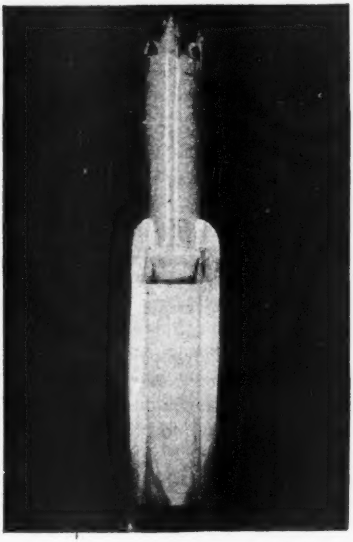
$$E=mc^2$$

where E is energy measured in ergs; m is mass in grams, and c is a constant: the velocity of light measured in centimeters per second.

Plenty of Power

From this equation it follows that the amount of energy contained in matter, weight for weight, is the same in all substances. Water, coal, sand or feathers should yield exactly the same amount of energy, pound for pound, depending only on the mass at hand.

And quite a tidy lot of energy it is, too. A single gram of matter should produce 9×10^{20} ergs, or about 37,000,000 horsepower-hours. Analogies attempting to bring this enormous outpouring of energy within the grasp of the imagination are many. It has been said, for example, that a lump of sugar would provide power enough to drive the Queen Mary across the ocean and back; that there is something like a billion times more energy left in the ashes of coal than the powerhouse obtained by burning the original fuel; that a pound of matter, converted into energy, would yield enough heat to melt thirty million tons of rock.



Atomic Power to Replace Liquid Fuel?

Clearly no rocket fuel at present known can even approach this. If atomic power were available—in useable form—fuel troubles would be among the least of our worries. Little journeys to the moon and planets could be undertaken with less fuss than now attends a shot of a couple of miles with gasoline and liquid oxygen.

But unfortunately Mr. Einstein failed to suggest a technique for the practical conversion of mass into energy,

and to date his mathematical equation remains of theoretical value only. The actual "conversions" or "liberations" of energy in atomic experimentation have been on a far less grand scale. They bear out the general belief that Einstein's equation expresses a true relation between matter and energy, but they offer little hope that we shall soon be zipping off to Mars on atomic power, or driving turbines with ashes instead of coal.*

Smashing the Atom

For it seems that the only practical way of doing anything to atoms is to bombard their nuclei with extremely small high-speed particles which are, themselves, fragments of atoms or atomic nuclei.

Two general types of bombarding machines are now in use. The most commonly employed is the cyclotron, or "magnetic frying pan", a device developed by Dr. Ernest O. Lawrence, of the University of California, who recently received the Nobel Prize for this work. The cyclotron consists of a huge electro-magnet, between the broad poles of which is fixed a flat vacuum chamber. Atomic particles in this pan are held in the proper plane by the magnetic flux, and meanwhile are booted along a spiral path by alterations of a current so synchronized as to change polarity at each half-circuit around the chamber. The effect is to accelerate the particles until at length their velocity permits them to escape the chamber, leaping out of the "frying pan" through a small window. The stream of particles forms a powerful though slightly diverging beam, capable in large machines of penetrating several feet of air.

In atomic experiments, the beam is directed against a small target of material to be bombarded. The results can be determined in various ways: by the use of electroscopes or Geiger counters to determine the nature and number of particles being given off, with the Wilson cloud chamber to study individual particles or "bursts", and finally by chemical or spectroscopic analysis to determine the actual transmutation of elements.

The Electrostatic Method

The other type of "atom smasher" now in use is essentially an electrostatic machine, which builds up a high electrical charge at one end of a vacuum tube, and uses the difference in potential to accelerate charge particles from one end of the tube to the other. Electrical focussing devices keep the beam of particles on track in the tube, and concentrate it into a compact pencil. This beam can be "sorted" into various beams according to mass or velocity of the particles by means of a magnetic analyser. The selected beam, as in the case of the cyclotron, is used to bombard a target.

Both types of machines have advantages peculiar to themselves, and likewise disadvantages. High voltages are rather easier to obtain with the cyclotron but the bombarding beam tends to diverge on the way to the target, and the beam is "mixed"—that is, it may have fast and snow particles, perhaps a varying mass, which make precise measurement of effects at differing velocities difficult or impossible. With the electrostatic machines, while they produce straight-flying homogenous beams, the higher voltages are

***However, it does appear that such atomic transmutations are probably the source of the energy that keeps the stars, including our sun, glowing.**

hard to get and maintain because of corona discharge, sparking over to the charging belts or nearby objects and other difficulties.

Tons of Equipment

So far the cyclotrons have enabled larger total quantities of material to be bombarded. More than a dozen of them are in operation in various physical laboratories, the most powerful being Dr. Lawrence's second cyclotron at the University of California. It weighs 220 tons; the poles of the magnet are 60 inches in diameter; it can generate beams of heavy hydorgen particles (deutrons) up to 16,000,000 volts, and heavier particles, such as the cores of helium atoms (alpha particles) up to 32,000,000 volts.

The two largest electrostatic machines now in operation are in the laboratories of the Carnegie Institution at Washington and the Westinghouse Electric & Manufacturing Company at East Pittsburgh. The Carnegie machine is ultimately expected to generate a beam at 5,000,000 volts. The Westinghouse machine may go even higher. Both are now in operation at voltages somewhat below this figure.

Liberating the Energy

The production of atomic energy presents the same problem with either the cyclotron or the electrostat. In a great many types of atomic disintegration by bombardment, actual energy is liberated—in the atom that is struck. But so empty is solid matter, and so bad the atomic marksmanship, direct hits are made on the order of once in each ten million shots. The input of energy on a given target is therefore considerably greater than the gain represented by the few atoms that are hit and disintegrated.

Three possibilities have been suggested which spur the hope that this may not always be true:

1. Some way may be found to improve the marksmanship.

2. It may be that more distintegrations can be produced with less energy, by finding some "resonance period" or "trigger mechanism" in the atomic nucleus which will cause it to fly apart more readily.

3. Energy may be released more cheaply by finding some element or compound in which the reaction continues of its own accord when once started by the bombarding machine.

Bettering the Marksmanship

As to the first possibility; no practical way has been suggested as yet. To produce disintegration, with attendant release of energy, not only the atom, but its nucleus must be hit directly. Small as atoms are, their relative emptiness is amazing. The distance from the nucleus of the hydrogen atom to its orbital electron, for example, may be 100,000 times the diameter of the nucleus.

Even so, there is evidence that the "marksmanship" improves as the voltage goes up. Dr. Lawrence recently declared that the yield of radioactive iodine at 16,000,000 volts is twenty times greater than at 8,000,00 volts. At this rate, there may be a point where bombardment to produce energy may become practical, but the voltages required would be of an order now beyond the capacity of any atom smasher.

Hunting the Atomic Trigger

As for the second suggestion: there is already some evidence that such a resonance period or trigger mechanism may be present, at least in some elements, notably lithium and carbon. These are markedly more affected by

bombarding streams at some velocities than at others. It may be that just the **right** velocity will spring such atoms like so many figure-four traps, releasing energy right and left.

Clearing Uranium

As for the third suggestion: it appears that such "chain-reaction" material may have already been found. About a year ago Professor Otto Hahn, of Berlin, bombarded uranium with neutrons, and produced such unexpected results that he immediately communicated with colleagues in Europe and the United States who hastened to repeat his experiments. Among the first to announce confirmation here were Drs. L. R. Hafstad and R. B. Roberts of the Carnegie Institution of Washington. It appears that when uranium is bombarded with **slow** neutrons, two complete new atoms are produced from each uranium atom hit. One of these is barium, or something in the barium group, and the other may be a radioactive form of one of half a dozen elements, including krypton, iodine, antimony, tin, molybdenum, zirconium, strontium or bromine. Which ones are produced depends on factors yet unknown.

This breakup of the big uranium atoms releases tremendous amounts of energy. In theory, the release should be about 200,000,000 electron volts; about one percent of the atom's mass being converted. Releases of about that order have actually been produced, the liberated energy appearing in the form of gamma radiation and the kinetic energy of sub-atomic particles.

The particles include neutrons. Since these are what started the first action, it seems strange that they do not strike neighboring atoms and continue the conflagration until all the uranium is consumed. Experimenters believe there are two reasons why the chain reaction does not take place.

One is that the experiments have so far been made with minute quantities of the material, and most of the neutrons simply escape into the air without producing any secondary disintegration. The other is that apparently it isn't ordinary uranium that disintegrates in this explosive and promising fashion, but a lighter isotope (an element of the same chemical qualities but different mass) of uranium.

Ordinary uranium has an atomic weight of 238; this lighter fellow weighs only 235. But for every light uranium atom in a run-of-mine mixture of the two types there are about 1,000 atoms of heavy uranium. And the heavy uranium gobbles up the fast neutrons without disintegrating, or at least without releasing any appreciable amount of energy. Consequently it puts out the incipient conflagration before it has a chance to start.

Concentrated Power

The answer is to concentrate the light type of uranium. Various possible methods of doing this have been suggested; none has yet proved practical.

Nobody knows whether the "chain-reaction" predicted by theory would actually take place anyhow. But, assuming it would, a pure mass of light uranium would certainly be a mighty interesting piece of baggage. The amount of energy releasable from a pound of such material would be equivalent to about 500,000 tons of coal. A couple of pounds could neatly blow Manhattan Island off the face of the earth.

THE ROCKETRY FORUM

Wherein Members Present Varied Viewpoints

(The war is very much in the minds of all of us these days, hence the interest and importance of this communication on rockets in national defense.—Ed.)

ANTI-AIRCRAFT ROCKETS

The indiscriminate bombing of unfortified cities is a threat to civilization. I believe the answer to offensive use of bombers is within our grasp, but that we do not fully realize it.

The rocket should be developed on the side of the defensive weapons against aircraft and not to give further superiority to nations using mass murder—and the threat of such destruction—as political and military forces of coercion to democratic and liberty loving peoples.

We should try to protect the present set-up of sea power because it is in better hands than is air power. Inventors devoting their efforts to weapons to destroy battleships are on the wrong track. The big problem is to find an effective antidote to offensive use of aircraft.

Specifically, what I propose is that the American Rocket Society, the scientists in our Universities, the engineers with access to large laboratories devoted to research, and the U. S. Army experts charged with the cognizance over new weapons get together on the solution of the following problem:

To make the use of bombers, in attack formations, too hazardous to justify the attempted destruction.

At present the best means of accomplishing this end seems to be through the use of controlled rockets carrying large charges of T. N. T. and Thermite.

There are several practicable methods of controlling rockets either if fired from the ground, or if carried aloft by defensive planes and launched in the manner of torpedoes against ships. The latter method has a special appeal, since it may be said to reduce a three dimensional problem to one of two dimensions—provided that the rocket carrier is fast enough to attain the same altitude as the attacking enemy formation, and can remain outside their effective machine-gun range.

The successful solution of this problem would redound to the eternal credit of the American Rocket Society, and to American inventors and scientists, since it might be the means of safeguarding the liberties not only of America, but of many small nations threatened with destruction.

It is suggested that all those who desire to take part in this worthy project write the American Rocket Society a letter volunteering their services and stating their aptitudes. In general the following types of engineering problems will need to be investigated: Ultrasonics, Radio Control, Ultra-violet and Infra-red beams, Aeronautics, Rocket Motors, Explosives and Incendiaries, Microphones, Photoelectric Cells, Gyroscopes, Searchlight types throwing invisible light, etc.

A start could be made with the 700 M. P. H. 85 lb. rockets with gyro control now in existence, provided the great scientist who has developed them would be willing to permit their use at this time.

—Lt. Com. J. M. Miller, U.S.N. (Ret.)

Should the combustion take place inside the motor or outside? Cedric Giles expounds a controversial theory —Ed.)

OUTSIDE NOZZLE REACTION

During a meeting of the American Rocket Society a few years ago, Mr. Nathan Carver outlined the theory of outside nozzle reaction, and at a recent meeting during a talk on rocket motor construction, described the theory a second time.

In this article, an attempt will be made to explain the principle and to define with more detail the hypothesis of obtaining the greatest jet reaction from the rocket motor, by employing outside nozzle reaction. This, of course, is in direct contrast to the orthodox theory that all combustion must be completed within the motor.

As the thrust of the rocket is secured by the counter action of the jet, and this action in turn is dependent upon the combustion of the gases forming the jet; the motor reaction is not only the resultant of the correct proportional mixing, metering and feed pressure of the propellants and overall design of the motor, but also is influenced directly by the position of the point of the greatest combustion temperature in the jet.

Complete combustion is attained only upon the accurate mixing of the fuels and this combining usually occurs over a distance from the inlet ports. It follows that in practice the correctly designed motor will not only control the flow of the gases, but will also govern the place of predominant combustion.

Motor reaction depends upon the explosive force (of the combustion of the propellants) pressing back against the oncoming stream of comburants.

In the rocket the stream of propellants is kept in a uniform mass flowing in a controlled direction by the restriction of the chamber and nozzle walls. Outside the nozzle aperture no such restriction takes place, and the compactness of the jet depends only upon its velocity. The higher the velocity the greater the distance beyond the nozzle mouth the jet will hold its form.

Since force of jet reaction is equal to mass of expelled gases times their velocity; by achieving a higher velocity a smaller mass of gases will be required to attain the same reaction. This principle results in a corresponding saving of initial fuels for the same thrust. Higher velocities also cause an extending of the combustion area over a greater area in line with the chamber-nozzle.

This moving of the completed combustion area to partly outside and beyond the nozzle aperture does not appear to result in a loss of reaction efficiency. In practice this principle of jet reaction promises to pay great dividends in the transfer of the highest temperature outside the motor, by consequent elimination of refractory linings and cooling systems with their attendant weights. In addition the motor can be made of metals whose melting points are far exceeded by the final flame temperature.

The controlling point of the combustion will usually be the position of the highest temperature while the entire combustion area will be responsible for transmitting to the rocket the work involved during the firing. In order to fill the equation $R=Vw/g$ it follows that a reaction must be found as long

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LETTERS TO THE EDITOR

GRAVITY is the arch-enemy of successful rocket performance. Any new theory of its nature deserves close attention, for it may contain a hint to the solution of a vexing problem. Mr. Nathan Carver, one of the oldest members of the Society, and renowned for his ingenious and unorothodx theories, spoke on a new theory of gravitation at the May meeting of last year. He forwards a few fundamentals of this theory for the benefit of those unable to attend the unusual lecture.

"Gravity is a push, not a pull, of static repulsion from space charges outside the planet.

"The absorption of static space charges by cold or relatively cold matter produces that unbalance of static repulsion charges that results in a pressure movement toward matter. This phenomena we know as gravity. The larger the sphere of matter the greater the absorption rate and pressure unbalance gradient, as there is more space charge absorbing matter back of each unit of surface.

"Mutual attraction of two bodies in space may be likened to two sponges submerged in water, as they absorb water they are pushed toward each other. This is due to their absorbing some of the water pressure between them and the action of the unabsorbed pressure surrounding them.

"The properties of static electricity are similar in many respects to those of matter, for matter is composed of static electricity. In the gaseous state we have radiation of static electricity. In the liquid state we have space charges surrounding electrons, similar to planets in a solar system. An interesting property of static charges is that they can be either very diffuse or so concentrated by inflow that a saturated condition is reached which is known as the solid state of matter. Matter in turn can be dispersed as static charges when heat and pressure conditions are just right. This is a requirement of atomic power.

"A better understanding of gravity is necessary to the conquest of space. This understanding may lead to improvements in jet reaction by the addition of static repulsion charges to the jet thrust"

THOUGH OF DOUBTFUL VALUE, except to philatelic specialists, powder rocket mail flights continue to be made in various countries. Since the first the technique has remained unchanged, a few lbs. of mail carried a short distance, in an overgrown 4th of July rocket. Sometimes a parachute is involved and always a tidy return from the sale of stamps.

Dr. Thomas A. Terry, instigator and general supervisor of the Cuban mail flights reported in the last issue forwards a few technical details.

"Prof. A. V. Funes was charged with the manufacture of the rocket.

"The rocket was finished in 2 months. It measured 60 inches from end to end, was 6 inches at its widest point, and weighed 10 lbs. As fuel it was charged with 3 lbs. of a special powder, secret formula of Dr. Fumes.

"For the initial experiment ten auxiliary rockets were added, and were placed in the middle and lower third of the rocket. This addition, plus mail, brought the total weight of the rocket at the moment of shooting to more than 15 lbs.

"On the first trial, made on October 1st, no good result was obtained because of a mistake in the charge and in lack of stability.

"The second trial which was effected two days later used the auxiliary rockets for the first time, and a rather regular trajectory of about 800 yards was covered. In the third trial due to heavy headwinds a strong deviation to the left occurred with a distance covered, however, of more than 300 yards.

"The official experiment took place on October 15th, on the shooting range of the Sport Club, before various civil and military authorities. For these experiments two rockets were launched.

"In the first one the representatives of the Secretary of Communications and the Philatelic Club of Cuba placed a package, prepared by the Post Office Department ,weighing 1 lb., and containing 250 letters. This rocket came to earth after having covered some distance.

"Then a second apparatus was shot (C-2) of the same size but of less weight (6 lbs.) and it covered a distance of more than 1500 meters in a vertical direction because of a mistake in the shooting angle. This rocket returned to earth by means of a parachute."

PHILATELIC CLUB OF CUBA
ROCKET-POSTAL COMMISSION

JET PROPULSION

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turing cost is only about ½ cent per lb.

Gasoline, used by Goddard and by the American Rocket Society in its early tests, requires 3½ times its weight of oxygen and is thus a more expensive fuel and only slightly more powerful per pound of mixture.

Paying about 5 cents per lb. for alcohol and 10 cents per lb. of oxygen brings a lb. of the mixture to 8½ cents. A motor with present 200 : 1 ratio would consume 5 lbs. of propellants per second per 1000 lbs. thrust. Each 1000 lbs. for 20 seconds take off would now cost $8.50 in fuel, when demand increases this should drop to $5 per 1000 lbs.

Installation

A large rocket motor mounted in the tail, or several smaller ones installed in the trailing edges of the wing, should not present any intricate problem of redesign. Stress analysis and redistribution of weight will be necessary, of course. The greater part of the weight of such an arrangement would be in the fuel which would be consumed during the take-off run, leaving the light motor and tanks as the only objects to be carried. Before a detailed mathematical analysis of such an installation can be made, test stand performance figures of a large motor will be necessary.

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OUTSIDE BURNING

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as a velocity is built up either within or partially outside the nozzle.

Intermittent burning of the propellants outside the nozzle in past tests has been attributed to incomplete burning due to improper mixtures. It is reasonable to believe that the outside combustion was caused in some cases by the moving of the point of highest temperature from inside the chamber to outside the nozzle.

As future rocket motors are constructed, using various types and quantities of propellants, different tank pressures, and other dissimilarities, the greatest temperature point will move in relation to these changes. With the trend toward higher jet velocities outside nozzle reaction should come into greater favor.

Cedric Giles

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